Long-term Durability of Root-end Sealing with 4-META/MMA-TBB Resin

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The purpose of this study was to compare root-end sealing using 4-META/MMA-TBB resin with that using conventional retrograde root filling technique, and thereby determine if 4-META/MMA-TBB resin offers long-term prevention against dye leakage from the root canal of human teeth. Thirty-five teeth had the apical 2.5 mm of the root resected. In the Sealing (SB) group, 4-META/MMA-TBB resin was applied to the resected surface. In the Filling (Am and EBA) groups, a root-end cavity was prepared and retrofilled with high copper amalgam alloy or reinforced zinc oxide-eugenol cement. Root canals were filled with methylene blue dye solution. Then, dye leakage outside the root canal was measured for 50 weeks.

The integrated amount of leakage in SB group was significantly lower than those in Am group (p<0.05) and EBA group (p<0.05). Therefore, it can be concluded that root-end sealing using 4-META/MMA-TBB resin resulted in better, long-term sealing than conventional retrograde root filling.

Key words : Apical surgery, Dye leakage, Retrograde filling, Root-end sealing

INTRODUCTION

Apical lesions must be treated to prevent spread of bacteria and the resultant inflammation to the surrounding tissues. Regrettably, conventional retrograde root filling is not always successful in this regard. In some cases, lack of success might stem from an impenetrable root canal, for example one that is obliterated, severely curved, or which contains a fractured instrument. In such situations, apicoectomy or intentional replantation followed by retrograde root filling may be required.

Over the years, many materials for retrograde root filling have been introduced. Clinical studies on these retrograde materials have reported a 59-88% success rate. The success rate was dependent upon a number of factors, including preoperative and operative conditions and methods employed. Some reports suggested that microleakage was not completely inhibited in vitro with amalgam, zinc oxide-eugenol cement or glass-ionomer cement. Yet, where infected material is present in the root canal, it is important that retrograde filling material is able to prevent leakage of infected substances from root canal to the periapical tissue. Applying bonding agent to resected root end without cavity preparation results in a good apical seal through sealing of both the root canal and dentinal tubules. Bonding agent has also been shown to provide adequate root-end sealing in clinical studies. These studies, however, did not address the possibility of leakage such as leakage of bacteria and their products from the root canal to the surrounding tissues.

Resin is known to be sensitive to moisture during application, and this could potentially lead to poor clinical results. 4-META/MMA-TBB resin has been widely used in orthopedic and prosthetic dentistry. It adheres to dentin both in vitro and in vivo, exhibits low cytotoxicity, is highly polymerized under wet conditions, and offers good biocompatibility after complete curing. It has been demonstrated that its sealing ability is unaffected by contamination with blood five seconds after application. Thus, it might be suitable for retrograde root sealing following apicoectomy or intentional replantation.

Cementum is a specialized mineralized tissue that covers the dentin surface. Therefore, adequate bonding to and sealing of cementum are required for root-end sealing. We have previously reported on durable adhesion between 4-META/MMA-TBB resin and cementum, which led to adequate sealing of the cementum in bovine teeth for up to six months. The purpose of the current study was to investigate whether root-end sealing using 4-META/MMA-TBB resin could provide long-term prevention against dye leakage from the root canal of human teeth, as compared with that using conventional retrograde root filling.

MATERIALS AND METHODS

Root canal preparation
Thirty-five extracted, single-rooted, human premolars with straight root canal were used in this study. Written consent was obtained from all informed donors for the use of each tooth. The teeth were stored at −20°C until ready for use. All teeth were prepared in a standardized manner by one operator. Superficial deposits and soft tissues were removed.
from the root of each tooth with a hand scaler. The
crowns were removed by dissection at the cement-
enamel junction using a diamond disc in a low-speed
handpiece. Once access was obtained, the working
length was visually determined by subtracting 0.5
mm from the length of a size 10 K-file (Maillefer,
Ballaigues, Switzerland) at the apical foramen. All
teeth were instrumented to a working length with a
size 40 K-file. The apical portion was prepared using
a conventional step-back technique and enlarged to
a size 60 K-file. Copious irrigation with running water
was performed throughout the cleaning and shaping
of the root canals. The prepared root canals were
not obturated.

All specimens had the apical 2.5 mm of the root
resected at 90-degree angle to the long axis of the
tooth with a #701 fissure bur (Syofu Inc., Kyoto,
Japan) in a low-speed handpiece with water coolant.
The exposed surfaces were then polished with #800
waterproof abrasive paper (Sankyo Rikagaku Co.
Ltd., Japan) to standardize the superficial morphol-
ogy. Following which, a coat of nail polish was ap-
plied to the entire root surface except the tip.

The prepared samples were randomly divided into
groups (SB, EBA, Am) of 10 specimens per
group, and a no-filling group of five specimens.

**Root-end sealing/retrograde root filling**

1) Sealing (SB) group
Plate-type, root-end cavity was prepared at the cut
surface of root apex with a #5 round bur in a low-
speed handpiece. An aqueous solution of 10% citric
acid and 3% ferric chloride (activator Green®, Sun
Medical Co. Ltd., Shiga, Japan) was applied to the
apex surface with a Benda® Brush (Centrix, Shelton,
CT, USA) for five seconds. 4-META/MMA-TBB
resin (Super Bond C&B®, clear type, Sun Medical Co.
Ltd., Shiga, Japan) was subsequently applied to the
treated surface according to the manufacturer's in-
structions using brush dip technique.

2) Filling (EBA and Am) groups
Root-end cavities of 2-mm diameter and 3-mm depth
were prepared with a #703 fissure bur (Shofu Inc.,
Kyoto, Japan) in a low-speed handpiece. Cavities
were retrofilled with Super EBA™ (Harry J
Bosworth Co., Skokie, IL, USA) in the filling (EBA)
group or SPHERICAL-D® (Shofu Inc., Kyoto, Japan)
in the filling (Am) group. Materials were condensed
into the cavity using a small plugger in accordance
with manufacturers’ instruction.

3) No-filling group
Root-end cavities of 2-mm diameter and 3-mm depth
were prepared with a #703 fissure bur (Shofu Inc.,
Kyoto, Japan) in a low-speed handpiece. Samples did
not receive any retrograde root filling.

**Dry leakage test**
Root canals were filled with 8 μl of 2% methylene
blue dye solution. Access openings were sealed with
glass-ionomer cement (GC Fuji, GP FAST®, GC Inc.,
Tokyo, Japan). The apical one-third of the roots
were then immersed in 100 μl of deionized water at
37°C. The amount of dye present in the water was
measured by spectrophotometry (Pharmacia Biotech
Novaspec), and the roots were re-immersed in 100 μl
of deionized water at Weeks 2, 5, 11, 24, 32, 40, and
50. To determine dye leakage amount, a linear re-
gression curve was constructed. This was accom-
plished by making serial dilutions of the original 2%
methylene blue dye solution and plotting the known
concentration versus the calculated absorbance using
a wavelength of 665 nm. The concentration of each
sample was calculated from this curve. The leakage
amount from the beginning of the study to each
measurement day was then plotted.

**Statistical analysis**
The data were analyzed by Kruskal-Wallis, Wilcoxon
signed-ranks, and Mann-Whitney U tests using sta-
tistics software (Stat View®, Abacus Concepts, CA,
USA). Differences at p<0.05 were considered statis-
tically significant.

**RESULTS**
There was no dye leakage throughout the experimen-
tal period where root-end sealing was performed
using Super Bond C&B®. In No-filling group, the in-
tegrated amount of leakage rapidly increased shortly
after the experimental period commenced. In Filling
(Am) group, the leakage amount increased from
Weeks 0 to 5, while in Filling (EBA) group there
was only a very gradual increase in integrated leak-
age.
In Sealing (SB) group, the integrated amount of leakage was significantly lower than that of:
- Filling (Am) group from Week 2 to the end of the experimental period (p<0.05);
- Filling (EBA) group after Week 11 (p<0.05); and
- No-filling group after Week 2.

As for Filling (EBA) group, its integrated amount of leakage was significantly lower than those of Filling (Am) and No-filling groups after Week 2 (Fig. 1). As for Filling (Am) group, its integrated amount of leakage was significantly lower than that of No-filling group after Week 2.

DISCUSSION

In this study, there was no dye leakage throughout the one-year experimental period where root-end sealing was performed using Super Bond C&B®. This suggests that root-end sealing with Super Bond C&B® may prevent the leakage of infected materials from the root canal to the surrounding periapical tissue if used clinically. In addition, this material may also prevent the infiltration of bacteria and inflammatory mediators from the periapical tissue to the root canal. In Filling (Am) group, leakage was found early in the experimental phase. In Filling (EBA) group, only a little leakage was detected after six months in all samples. It was reported that a gap exists between cavity wall and amalgam. When amalgam was filled in root-end cavity with unfilled canal, leakage could have occurred because of insufficient amalgam being condensed into the cavity.

In previous studies using dye, the root and retrofilling materials were sectioned and the dye penetration depth measured. In these studies, sealing ability was determined using small sample sizes. This meant that leakage from lateral canals or dentinal tubules could not be measured. Hence, the results of these studies might not conclusively reflect the total leakage from the root canal to the periapical tissue in each sample. Even a small leakage amount may result in re-infection of the periapical tissue by bacteria from the root canal. In the current study, simulated root apex surgery and retrograde filling or root-end sealing were performed, and dye leakage outside the root canal was measured. It is thought that exposed lateral canals or dentinal tubules on the resected root-end are communicating with root-end cavity. Therefore, leakage might have occurred through the lateral canals or dentinal tubules due to coronal gap between cavity wall and filling material in the Am and EBA groups.

The SB samples did not exhibit leakage probably because the entire exposed dentin surface was covered with resin. Previous results suggested that the bond strength of Super Bond C&B® to cementum and dentin significantly decreased within three months and then remained stable. In this study, seal durability seemed to maintain for one year. Nevertheless, further investigation on durability of long-term sealing ability of Super Bond C&B® in vivo is necessary.

CONCLUSION

Based on the results of this study, root-end sealing using 4-META/MMA-TBB resin prevented dye leakage from the root canal.

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